NAVI-SYSTEM: AUTOMATED SURVEY SYSTEM FOR MARKING WORK IN CONSTRUCTION SITE

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In construction of nuclear facility, there are metal works to secure and support these pipes to walls and floors. In addition, it is required to construct opening where these pipes pass through walls and floors. Metal plates are encased in and openings are installed at walls and floors while placing reinforcement. Current work of setting out encased metal plates and opening is conducted by a team of two workers who measures positions based on base line established on walls and floors by using a tape, as referring to drawings, and marks the positions on reinforcement. This work of setting out requires skilled workers and is time-consuming, and results in bottleneck of process of work. This paper reports that navigation system to detect position was developed so that any worker could easily handle it for setting out in construction site.

Keywords: nuclear facility, marking, total station, CAD, three-dimensional measurement

1. INTRODUCTION

Like a sort of chemical plant, nuclear facility has large tanks and complex equipment all over the place. The equipment is joined by variety of pipes, which pass through walls and floors and go crosswise and lengthwise inside the building. Some of walls and floors reach two meters thick.

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2. PROCESS OF WORK

Work to mark lines as for metal plates and sleeves is conducted along with process of work as shown in Figure 1. This work is to mark position of ends of metal plates and sleeves on previously assembled reinforcement.

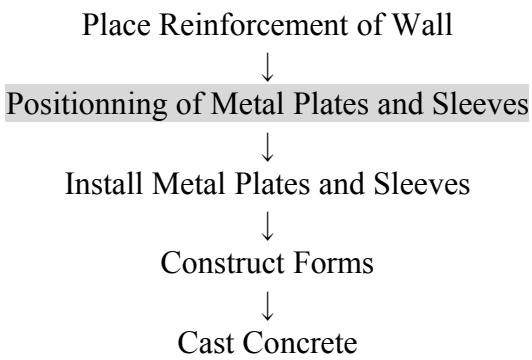

Figure 1. Process of Work

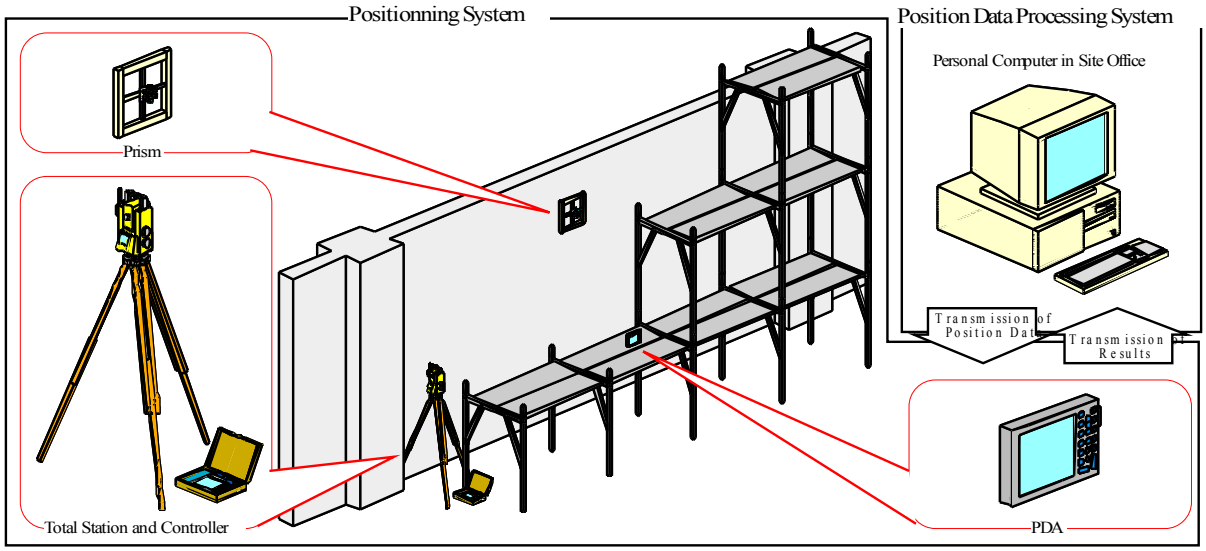

Figure 2. Configuration of Automated Survey System for Marking Work

3. OUTLINE OF AUTOMATED SURVEY SYSTEM FOR MARKING WORK

Navigation system to detect position was developed so that any worker could easily handle it for marking in construction site. The navigation system is composed of position data processing system and positioning system for marking. The former system is to detect positions of encased metal plates and opening based on CAD data of drawings. The latter system is to confirm positions to be set and to take worker to the positions. (Figure 2)

4. OUTLINE OF POSITION DATA PROCESSING SYSTEM

In the position data processing system, CAD data pertaining to positions of encased metal plates and openings which are provided by plant manufacturers, are converted to three-dimensional data based on combination of plan and elevation; positions, sorts and sizes of encased metal plates and openings are detected. In provided drawings, conventions to draw metal plates and sleeves are arranged among plant manufacturers.

4.1 Legend of Metal Plates and Sleeves in Drawings

There are fifteen sorts of encased metal plates. In drawings, they are drawn in full-size and marked and distinguished by symbols as shown in Table 1. Sleeves are changed in size according to positions to be fixed. Openings are drawn in full-size and marked and distinguished by symbol "×" as shown in Table 1.

	Type	Mark	Size (H×W×T)
Metal Plate	H1		250×250×12t
	H2		300×300×16t
	H3		300×300×22t
	H4		400×150×16t
	N1		250×250×12t
	N2		300×300×16t
	N3		250×150×12t
	HA		250×250×12t
	HB		300×300×15t
	HC		300×300×25t
	HD		400×150×15t
	NA		250×250×12t
	NB		300×300×16t
	NC		250×150×12t
	ND		350×350×12t

	Mark	Type
Sleeve		Circular Sect
		Box Section

Table 1. Symbols of Metal Plates and Sleeves

4.2 Method to Distinguish Metal Plates and Sleeves in Drawings

Positions of metal plates and sleeves in elevation of wall are distinguished by finding length of lines and paint to cover them based on conventions in Table 1. As for positions of distinguished metal plates and sleeves in the round, the coordinates of the center are stored. In case of the box section sleeves being distinguished, the four-sided coordinates are stored.

4.3 Conversion to Three-dimensional Data

Since the stored coordinates of distinguished metal plates and sleeves are founded on the elevation of wall, it is required to convert them to three-dimensional coordinates based on the whole space of construction site. As shown in Figure 3, conversion to three-dimensional data is executed based on combination of plan and elevation of each floor.

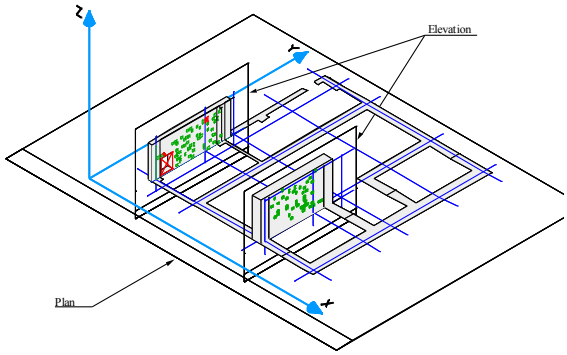

Figure 3. Method of Conversion to Three-dimensional Coordinates

4.4 Distinguished Coordinates

Figure 4 shows snapshot of positions of distinguished metal plates and sleeves displayed by the position data processing system.

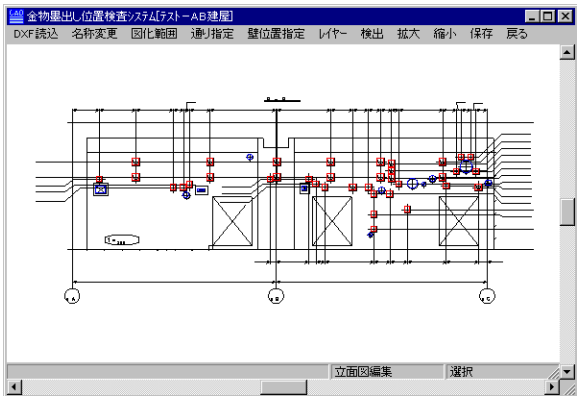

Figure 4. Positions of Metal Plates and Sleeves

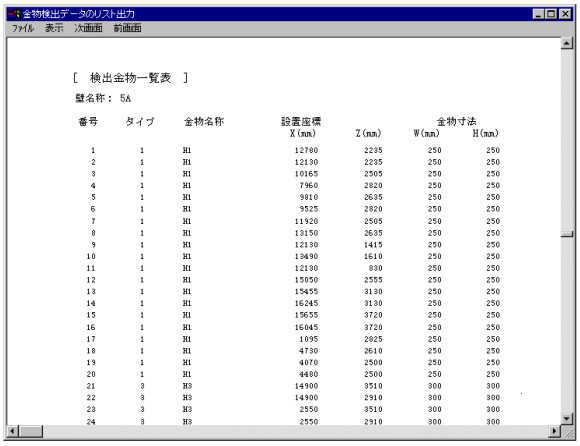

Figure 5. Three-dimensional Data Stored in Position Data Processing System

Figure 5 shows example of three-dimensional data stored in the position data processing system. Distinguished coordinates are transmitted to wearable terminal tools of the positioning system and are used for work for marking in construction site.

5. POSITIONNING SYSTEM

The positioning system is composed of:

- Laser survey instrument and control terminal (Total station),
- Terminal tool that worker wears, and
- Prism to confirm positions of installations.

The positioning system takes worker with the prism and the terminal tools to positions of metal plates and sleeves being installed that are distinguished by the position data processing system. The prism that worker wear shows her/him where she/he is and direction and distance to positions to be set out where metal plates and sleeves are installed, so that she/he can navigate and reach the positions in her/his construction site.

5.1 Prism

Worker for marking work always wear the prism that is one of subjects of the laser survey instrument. Worker handles the prism according to instructions from the terminal tool. Worker finds positions to be set and then marks positions where metal plates and sleeves are installed. Figure 6 shows example of positionning work.

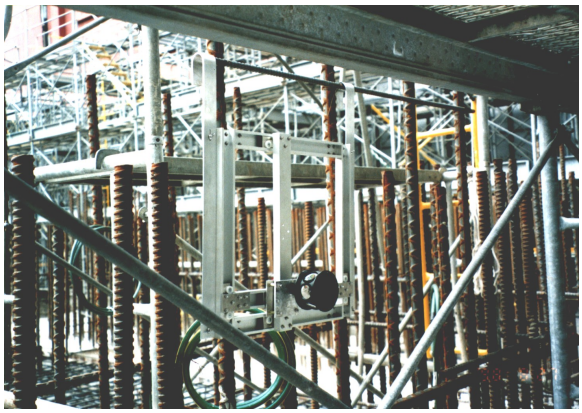

Figure 6. Prism and Prism Holder

5.2 Laser Survey Instrument and Control Terminal

The laser survey instrument (Total station) automatically follows the prism that worker holds and measures the position at interval of five seconds. The measured data are automatically transmitted to the control terminal. The control terminal automatically transmits the measured data to the terminal tool, which worker wears, and also functions to control the laser survey instrument.

Figure 7. Laser Survey Instrument

5.3 Wearable Terminal Tool

The wearable terminal tool carries data pertaining to positions where metal plates and sleeves are installed. Worker can choose metal plates to be installed and positioning it in order as watching display of the wearable terminal tool. Positioning work is conducted according to instructions from navigation display, which shows distance to metal plates and sleeves to be set out based on measured data being transmitted by the control terminal of the laser survey instrument. Figure 8 shows state of handling the control terminal. Figure 9 shows example of the navigation display.

Figure 10 shows sate of work to set out. Figure 11 shows work to mark position to be set on reinforcement.

Figure 8. State of Handling Control Terminal

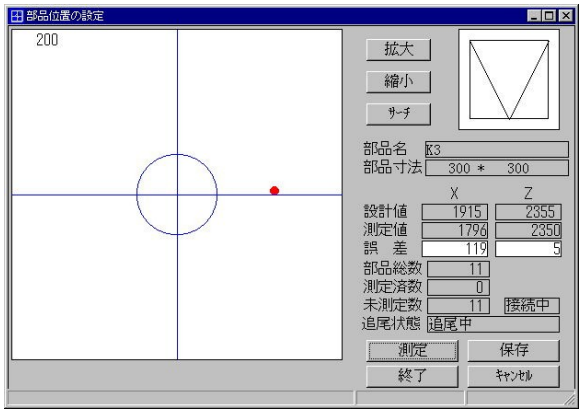

Figure 9. Example of Navigation Display

Figure 10. State of Work Practice

Figure 11. Marking Work to Position to be Set Out on Reinforcement

Targeted position of marking is shown as red point in the navigation display. Worker of marking work moves the prism in direction to the red point and can find position to be set. Sorts and positions of metal plates and sleeves to be set are shown in the navigation display.

When positioning work is finished, current position data is stored in the wearable terminal tool. Consequently, it means to record positioning data into the wearable terminal tool. In addition, the wearable terminal tool has function to show number of unfinished works that is calculated based on data of finished works.

6. RESULTS

This system enables worker to accurately set out positions of metal plates and sleeves in short time. Data of positions of metal plates and sleeves to be finished to set out are stored in the terminal tool. Accordingly, worker and supervisor can easily confirm performance of marking work and can avoid overlooking unfinished works. Consequently, this system being developed is effective to improve quality of construction.

7. CONCLUSION

The automated survey system for marking work being developed has been applied to construction project of nuclear facility in Japan. In consequence, the effectiveness as mentioned above was confirmed.

In addition to work of setting out positions of metal plates and sleeves being installed in walls, concept of the automated survey system for marking work can be applied to work to set out at floor and in building with complicated shape. It is expected that the automated survey system for marking work will be applied to variety of building construction.